THIRTY KNOTS AN HOUR TO EUROPE.

POSSIBILITIES OF SPEED ON THE ATLANTIC.

BY J. H. BILES, PROFESSOR OF NAVAL ARCHITECTURE, UNIVERSITY OF GLASGOW, AND DESIGNER OF THE "PARIS" AND THE "NEW YORK."

THE speed of Atlantic steamships has become a subject of national interest to Americans, for a majority of the cabin passengers carried belong to the United States. But until a few weeks ago, when the "Paris" and "New York" were transferred to the new American Line from the old Inman Line, there was not a vessel in the trade flying the American flag or representing, except to a very small extent, American capital. It is now no secret that these two vessels were projected and owned by Americans and would have carried the American flag from the time they were launched had the laws of the United States been the same in relation to ships as they are in Great Britain. Recent legislation in the States has now, however, made it possible for the owners of the "New York" and the "Paris" to construct a fleet of similar vessels in America which shall have a reasonable prospect of giving a proper profit to their owners, and shall make possible a bi-weekly service of steamers to Europe, by means of which Americans shall be enabled to travel in American-built and American-owned ships at as high a speed as engineering science can give, consistently with the condition of securing a fair interest upon the money invested in such ships.

To decide what that speed shall be is the problem which must be attempted by those who are responsible for insuring a proper profit upon the money spent. Given, that a certain average number of passengers, paying an average rate of so many dollars, will present themselves to be carried, and that a certain number of tons of freight will be forthcoming, which will add a cer-

tain amount to the earnings of the shipowner, it is then within the power of the manager of such a line of steamers to say how much he can spare, from the money so received, to pay for means of propulsion, insurance, depreciation, repairs, and interest on first cost. From such figures he could readily determine the speed, beyond which the interest would not be earned. But no one can say with any degree of accuracy how many passengers will travel if ships are run at speeds much in excess of present ones, or how much the existence of a regular bi-weekly service of high-speed ships would develop traffic which at present does not exist. So the questions of speed and volume of trade react upon each other in a way which it is difficult to foresee.

The attempt to attain increased speed must therefore be looked upon commercially as being more or less of an experiment. The increased cost of producing the increased speed can only lead to a commercial success if that increased speed is accompanied by an increase in the volume of trade. This increased volume of trade must be of advantage to the country whose flag the ship flies, as well as to the shipowner whose enterprise has produced the ship. The shipowner cannot tell whether his ships will pay until they have actually been at work for some time, and have really developed the increased traffic, so that he, unaided, practically takes all the risk. If, however, the people or their representatives take a wide enough view of this question, they may assist the shipowner by subsidy to enable him to minimize the risk of commercial failure. If the traffic develops sufficiently to insure commercial success, the country will probably have gained much more than it has paid for, and will be in a condition to continue the assistance to the shipowner, provided that he continues to take such steps as shall insure from time to time a continued increase of speed.

Thus, the first element of increased speed is the reduction of the risk of commercial failure. Government subvention, judiciously given, seems to be the most certain way, and will be in the end the cheapest way for a country to obtain increased speed in its cross-sea means of transportation. For many classes of freight, and probably for some classes of passengers, the increase of speed would not be accompanied by an increase in the volume of trade. With such complete telegraphic communication as now exists, rapid transit of freight of many kinds is of small import-

ance. The volume of these goods coming into a country may be carried by a small number of ships moving at a high rate of speed, or by a larger number moving at a slower rate. The question of the cheapest method of moving these goods is of more importance than the speed at which they are moved. It is very much like the flow in a pipe of water to a city. It may be done by means of a small pipe, the velocity of the water being great, and the loss of energy by the friction of the water in the pipe being also great. Or it may be done by means of a large pipe, the water moving in it slowly. In the latter case the loss will be less, but the first cost of the pipe will be more, and only the experienced engineer can tell just at what point the advantage of increased size of pipe and reduced speed balances the disadvantage of increased first cost. So it is in freight such as grain, coal, cotton, etc., where the total volume delivered into a country is all that the receivers are interested in. The question of the size of ship, the number and speed of the ships, is one that depends upon the relation of what may be called loss by friction in running (in other words, the expense of getting the freight through the water) to the first cost of the machine necessary to do the work.

This problem is modified to some extent by the distance which the cargo has to be transported. Some of the weight carried is necessarily the fuel to propel the ship and cargo. Hence the cargo delivered is really the weight put on board, less the amount of coal consumed on the way. When the distance is short and the speed not great, the amount of coal burnt is small, and the net cargo delivered is not much reduced. If the cargo be carried at a high speed, the amount of coal burnt on the way is naturally much more than at a low speed. But if the distance be short the total deduction of cargo-carrying is not large whether the speed be high or low, and consequently for short distances the loss of cargo-carrying due to high speed is not great. The number of voyages is increased with the higher speed, and the amount of cargo delivered per year is thereby correspondingly increased. Hence for short distances and a given size of ship, cargo can be carried at a higher speed than it can for longer distances, with the same commercial efficiency.

If for cargo we substitute all the part of a ship which goes to make up passenger convenience, comfort and accommodation, the same proposition will hold good. All these things mean weight.

and though they are not removable, as cargo is, they can be treated for sea-going purposes in exactly the same way.

Hence, one of the possibilities of increased speed lies in reducing the length in miles of the sea passage. Suppose that it were desirable to sail from Halifax to Galway instead of from New York to Southampton or Liverpool, the distance would be reduced by about eight hundred miles. In one of the present twenty-knot vessels, such as the "Paris," the amount of coal saved would be over five hundred tons. This saving of coal could be represented in a new ship of the same dimensions by an addition to the motive power, and consequently to the speed also. This increase of speed again in its turn would reduce the quantity of fuel carried, on account of the reduced time during which the ship would be burning coal. The speed gained for these reasons would be almost a knot an hour. Hence from a change of the length of sea passage we have a gain in speed per hour, which would on the New York and Queenstown route be equivalent to a shortening of time by seven hours. The time required to do the reduced distance at the increased speed would be four and a half days. Whether such a route, with its increased number of changes of vehicles, will ever become commercially a success need not be dealt with in this connection. The point to be noticed is that the shortening of the distance to be run tends to increase the speed per hour of the run, and is, therefore, one of the possibilities of augmented ocean speed.

It can readily be seen that, as most of our high-speed vessels carry some cargo, the same increase of speed which is gained by carrying a reduced quantity of fuel may be gained by carrying an amount of cargo reduced by the same quantity. Thus, the fastest ships, which at present carry one thousand to fifteen hundred tons of cargo, could have had one knot per hour more speed if their weight-carrying capability had been reduced by five hundred tons. It must not be supposed that this result could be attained in the present ships by merely omitting to take five hundred tons of their cargo. These five hundred tons must be replaced by additional motive power before this extra knot can be got. But the point to be noted is that the possibility of increased speed lies in the abandonment of all cargo-carrying in high-speed passenger steamers. No doubt there are some classes of cargo which require to be transported at a high rate of speed. But if

it is considered desirable to have ships which shall carry passengers and mails at the highest possible rate of speed, then cargo-carrying must be relegated to slower ships. Here, then, is another possible increase of speed. Could our fastest ships replace their cargo by motive power, they could add from one and a half to two knots per hour to their speed.

The possible increases of speed already named are dependent upon matters which the shipowner must determine and decide. But the marine designer will probably be expected to supply his share of possibilities. He can do nothing to lessen the actual distance between the points of departure and arrival, unless he is considered responsible for wild steering and its consequent increase of the distance actually run. How much is lost from this cause it is very difficult to determine, but when record-breaking depends on minutes in a run of six days, good steering must be an important factor. But if distance cannot be shortened by the designer he can take an important share in reducing the weight to be carried. The introduction of steel and the economy of the triple expansion engine have enabled him to add knots to the speed of Atlantic ships.

Steel of greater strength than that now commonly used for shipbuilding was adopted for special parts of some warships somewhere in the sixties, but it was not until 1875 that steel, as we know it, was an assured success. Its price at that time was three times its present price. To-day we have a metal known as nickel steel, which occupies the same position in relation to the steel of common use to-day that that steel did to iron in 1875. It is just the same price to-day that steel was then. It is, at this price, 40 to 50 per cent. stronger than ordinary steel, which was, in its turn, 40 to 50 per cent. stronger than iron. Shall we get this metal into common use in the next ten years? If we do, we shall be able to add a knot an hour to our new steamers by its introduction. This possibility of increased speed would probably have become an accomplished fact in the new American Line vessels, were it not for the great first cost of the metal. But we ought to be able to take full advantage of this superior metal in some of the vessels which will be built in the next ten years.

In the machinery which propels the vessel we do not seem to be within sight of any great development which will, *per se*, be the cause of increase of speed. There has been a steady increase

of efficiency of mechanism in the last ten years. The number of revolutions of our best engines has been steadily increasing, the fastest vessels averaging ninety revolutions per minute as against sixty in the early part of the last decade. This means that we are getting more work out of the same-sized machinery. This development will slowly continue, but whether it will reach any large advance upon present practice seems doubtful. The advantage of this development cannot easily be expressed in knots per hour, but it has within itself the possibility of increased speed.

The boilers which give the steam to the machinery are much more susceptible of modification.

There are many types used at present for different purposes, and so much do they vary that some types give three times as much work for every ton of weight that others give. Unfortunately it happens that the boilers in present use are of the heaviest type, and though marine engineers are most anxious to get as much work out of every ton of weight as possible, there has not yet been sufficient experience of continuous sea-going work to justify the adoption of the lighter types of boiler on a large scale. Experiments have been made on board ship with varying success, but these experiments have been almost completely confined to ships of war, where the object sought has rather been to attain the greatest power for a short period than to find what results could be maintained over long periods, such as an Atlantic steamer must be capable of undertaking. Until some one undertakes an experiment with the lighter types of boilers in a vessel which has to perform long-steaming operations, it is not likely that a considerable reduction in the weight of boilers due to a change of type can take place. There is every inducement on the part of those owners of fast Atlantic ships, who are anxious to have still faster ships, to get such an experiment tried.

The results of trials under favorable conditions of different kinds of boilers can be taken as a measure of their relative steaming capabilities. If it can be shown that some one particular type of light boiler of the many which have been tried is capable of reproducing at sea over long distances the superiority which it has shown on trial, then we shall have at once a possible increase of speed due to the adoption of this type of boiler. If, for instance, the locomotive type of boiler, with which nearly all tor-

pedo boats are fitted, can be shown to give on prolonged voyages only two-thirds of its relative superiority on trial, we have at once the possibility of more than a knot an hour of increased speed. This type of boiler is one of the lightest of a class known as tubular boilers, in which the water is outside of the tubes and the fire is inside. There are some very successful boilers of a class known as the tubulous boilers, where the water is inside the tubes and the fire is outside. The performance of these boilers in relation to weight is much better than any of the tubular type. The development of this type promises to be more rapid in America than in Europe, and we may see before long the New World leading the Old in this matter. When this happens the reward of higher speed will certainly follow.

The machinery and boilers are the part of the motive power which is the product of man's skill. The other part is the fuel. The details of the machinery are modified by the kind of fuel which man selects as the best. Hitherto the generally-adopted fuel has been coal. The amount of work done per ton of coal varies considerably, but, except in the matter of expense, there is obviously no reason for selecting for use on shipboard any coal but that which gives the largest amount of work per ton of weight. At present in the fastest ships it is found advantageous to use the most efficient coal, even though the cost per ton is more than fifty per cent. higher than that of fairly-efficient coal. Five per cent. gained in efficiency per ton of coal means nearly a quarter of a knot in speed on a twenty-knot vessel, or nearly two hours on the run between New York and Queenstown. It is therefore obvious that complete knowledge of the work-producing capabilities of the different kinds of fuel is an absolute necessity on the part of the marine designer in order that he may give as much machinery and boiler power as possible consistent with carrying just sufficient coal to enable the vessel to complete her voyage at her highest possible speed. Any deviation from this proper division can only be made at the expense of speed. Too little coal will cause a reduction of speed, as the fuel will have to be economized and power reduced in order to complete the voyage. Too much fuel means that a weight of coal will remain at the end of the voyage which would have served to increase the speed had it been employed partly as extra machinery and partly as extra fuel to drive the extra machinery.

The possibility of obtaining a greater amount of work per ton of fuel is dependent partly upon the possibility of the improved combustion of the fuels at present in use, and partly upon the possibility of the adoption of other fuels with improved work-producing capabilities. It is to the former possibility that attention has been directed within the last few years. The principles of the combustion of coal in boiler furnaces are beginning to be better understood. The adoption of forced draught in various forms has directed attention to the better utilization of the heat which can be developed by this method, and also to the more economical production of that heat. To obtain some measure of the possibilities of increased work by improvements of this nature, it may be stated that boilers of the ordinary marine type have been successfully worked on land for several consecutive days under conditions which gave at least fifty per cent. more work per ton of boiler than our best marine boilers are at present giving. The amount of coal burnt in relation to the work done was better than in ordinary practice; but the point to be noted is that the improved methods of combustion and of utilizing of heat, together, enabled a very much greater amount of work per ton of boiler to be maintained. Whether an equivalent improvement can take place in the results of combustion by these methods in the lighter types of boilers already referred to has not been demonstrated, but there are valid reasons for supposing that such can be obtained. If, therefore, we can combine the advantage of the lighter boiler, with the improved methods of combustion, we may obtain an increased amount of work per ton of boiler and a consequent further increase of speed.

As to the possibility of adopting other fuels than coal, there can be no doubt that for the purpose of getting a ship across the Atlantic at the quickest speed there is at least one fuel that would attain this purpose better than coal. The burning of petroleum in boilers has long since passed beyond the experimental stage as an engineer's question. The cost of this fuel has prevented its adoption as a steam-producing agent everywhere except in the oil-producing regions. It is stated that the supplies are so limited that it is impracticable to adopt oil for ships, as the enormous quantities that would be required would soon make the prices prohibitive. Experiments on an extensive scale have shown that one ton of oil will do as much work as two tons of the best coal.

Here, then, we have a means of saving one-half of the weight of fuel to be carried. The weight saved can be utilized to give a knot and a half more speed.

The question of adopting oil for the purpose of obtaining increased speed in trans-Atlantic travel is one which cannot fail to be interesting to Americans. If the greatest attainable speed is of national importance and that attainment is only possible by the use of oil fuel, the nation possessing the control of oil supplies can, other thiugs being equal, have the fastest ships as long as oil maintains its superiority as a fuel. The supply of oil to these ships at a commercially practicable rate would have to be insured. This might only be practicable by preventing its use for other purposes of less importance nationally. But there are other difficulties which have first to be overcome before oil as a fuel for fast passenger steamships can be generally adopted, not the least of which is the accustoming of passengers to the idea that an oil-fuel ship is as safe as a coal-fuel one. The engineering difficulties are not great, and a much more conveniently-worked ship could be designed if oil fuel were adopted.

In the foregoing some possibilities of increased speed have been enumerated. They may not all be cumulative in their effect, but we may roughly say that should the nickel-steel become cheap enough, and should a lighter type of boiler, such as the locomotive type, become a certain success for continuous sea-going work, the speed may be increased by two knots above present speeds. If oil be the fuel used, the speed may be increased three and a half knots. In other words, the time record from Sandy Hook to Queenstown would be reduced from five days fifteen hours to four days sixteen hours.

The foregoing remarks are on the assumption that no increase is made in the dimensions of the vessels at present doing their tweuty knots average sea speed. If any of the principal dimensions, length, breadth, or draught of water be increased, there is a further possibility of increasing speed. Length is the most valuable addition which can be made with a view to increasing speed. Strange as it may seem, it is possible to make some particular forms of vessels go faster for the same engine power by adding to their length. It is possible with some forms to double all their dimensions and to obtain the same speed for half the power. This does not hold in the case of vessels of the form

of our best Atlantic liners. But fifty feet added to the length of one of them, while adding nearly ten per cent. to its gross money-earning capabilities, would not necessitate an addition of more than four per cent. to the engine power to attain the same speed.

Draught is a most valuable addition to a vessel's potentialities for speed, almost as valuable as length. The limitations upon the dimensions of vessels which are due to harbor and dock accommodations are gradually becoming less. But the limitation which retreats least rapidly is that of draught. If we could have added four feet to the draught of our present steamers, making their loading draught thirty feet instead of twenty-six, they could have been designed to have a speed of one and a quarter knots more, or to have a gain of about eight hours on the run across. The harbor authorities on the English side are increasing their draughts. Southampton will very shortly have facilities for vessels of thirty feet draught at all times of the tide.

Increased breadth is not so productive of increased speed as increased length and draught, although breadth must be increased as draught increases.

If, therefore, in addition to improvements in fuel and machinery, it is possible to increase dimensions, we may look for very considerable increases of speed. If the commercial conditions can be fulfilled there is every reason to expect much higher speeds in the next ten years. The fulfilment of the necessary commercial considerations should be insured by the nation. The increase of speed is increase of postal facilities, and the delivery of passengers is postal work in its widest sense. The risk of commercial success in the matter of delivery of letters has been taken by the Government of all civilized countries, and it is not probable that private enterprise could do as well as the postal authorities now do. It does not therefore seem unreasonable to look to the nation to give encouragement to the increase of speed by taking a large share of the risk which accompanies the endeavor to attain this increase. The recent arrangements made by the United States Government to encourage the building of mail steamers in America is a recognition of this principle, but it seems to go scarcely far enough. Take, for instance, the North Atlantic mail service, for which several twenty-knot ships are to be built. Great inducement is offered to make these vessels attain 20-knot speed, but no inducement whatever is given to make them

do more. Hence the arrangements so admirably made to give 20-knot ships will tend to prevent higher speeds from being sought for. If something more should be done in this direction by offering an additional subsidy for each successive increment of speed, obtained above the contract amount, as is done already in the case of the war ships built for the United States Navy, there would then be a very considerable chance of progressive increase of speed. To a nation which is spending so much upon commerce-destroyers, such as the "Columbia," it would be a trifling matter to spend a comparatively small additional sum per year to alter the character of their mail contracts so that a steady development of increased speed should be encouraged. If this were done, the mail steamers would be of more service in time of peace and more formidable in time of war when used as armed cruisers.

The question may now naturally be asked, Should all the possibilities indicated herein be fulfilled, what speed are we likely to reach in, say, the next ten years? Shall we add as many knots per hour to the best speed in the next ten as has been done in the last? Ten years ago the time to cross from New York to Liverpool was practically eight days. The best that has been done up till now is a little over six days. Will the best time in ten years hence be a little over four days? There seems to be good reason to believe that it will be. To leave New York at noon and arrive at Southampton at noon on the fourth day out necessitates a speed of thirty knots an hour. A vessel 1,000 feet long, 100 feet wide, with a draught of water of thirty feet, with a structure built of stronger steel than that at present adopted, with lightened boilers, with oil or some equally light fuel instead of coal, and with the steady general improvements in methods of construction and management of ships and machinery, such a vessel will be capable of crossing the Atlantic in a little over four days. The design of such a vessel will involve the consideration of many problems of structural detail, but there is nothing insuperable in any of the difficulties which will accompany such a project. Whether the carrying out of such a work will be done in the Old or in the New World time can only show, but when it is undertaken, whether by the Old or the New, there is no reason to doubt that it will be successfully carried out.

J. H. BILES.